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Complementary Scientific Review of the Proposed Alberta–Pacific Pulp Mill Project Environmental Impact Assessment

Key Findings and Recommendations

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H4048
Helsinki, 29th June, 1990

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prepared for Alberta Research Council
ARC Contribution Series 1856

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COMPLEMENTARY SCIENTIFIC REVIEW OF THE ALBERTA-PACIFIC PULP MILL PROJECT

Key Finding and Recommendations

This summary report is respectfully submitted to the Alberta Research Council.

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DATED at the city of Helsinki, Finland, this 9th day of July, 1990.

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COMPLEMENTARY SCIENTIFIC REVIEW OF THE PROPOSED ALBERTA-PACIFIC PULP MILL PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

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SUMMARY

The Complementary Scientific Review of the Proposed Alberta-Pacific Pulp Mill Project (ALPAC) was carried out to study the earlier environmental impact assessment (EIA) and to find complementary scientific data to better assess the potential and probable effects of the proposed development. Unlike the previous Review Board the team also reviewed the effluent releases and water pollution control measures in the context of the entire Athabasca and Peace River watersheds.

The terms of reference for this project were to review all of the available data on the effects of chlorinated organic compounds and the biological oxygen demand that would be discharged in the pulp mill effluents. Air pollution, solid waste and other environmental issues, less crucial than the problems posed by water pollution, would be discussed only in relation to specific questions that were not completely addressed in the previous review in 1989.

The team established for the complementary review had the opportunity to discuss the project with three members of the original Review Board: Mr. Ron Epp, Prof. Bill Ross and Prof. David Schindler, each of whom gave an excellent briefing on the work of the board. They also provided the team valuable advice on open questions and local conditions, which were very important for focusing the authors' efforts on the essential issues in the somewhat limited time available.

The report includes a comprehensive technical evaluation of the proposed ALPAC bleached kraft pulp mill. Special attention has been paid to the water pollution issues, focusing on potential methods of restricting the formation and discharge of AOX (adsorbable organic halides, i.e. total organic chlorine). The study is based on the same technical proposal that was presented in public hearings and in the report of the original EIA Review Board. However, it is recognized that in the end of April ALPAC issued a more ambitious technical proposal, which at this time remains confidential. The revised ALPAC proposal is known to describe technologies for improving the bleaching process which is claimed to further reduce the formation and release of chlorinated organic compounds. Such an improvement would have some additional impact on reducing the toxic effects of chlorinated organic compounds on the environment rather than reducing any other single loading parameter. As the new ALPAC proposal remains confidential, a short description of other possibilities to reduce the formation of AOX compounds has been included by the authors of this report. According to recent Canadian research, the benefits of AOX reduction to levels below 1 kg AOX/ADt are rather limited; however it would decrease the probability of discovering some new hazardous chlorine compounds at a later date .

In this context the ALPAC mill could not be reviewed alone, so data on other operating mills and mills under construction were included. The past emission levels from the bleached kraft pulp mill at Hinton were estimated for different periods of operation and their effects were assessed to the extent relevant and practical. The Hinton pulp mill has been in operation on the upper reach of the Athabasca River since 1957 and with modern technology its capacity has been doubled in the past two years. Due to the natural sedimentation conditions described in detail in chapter 4, the probability of finding dioxins and furans in the main stream of Athabasca River is almost negligible. It seems more likely that the dioxin and furan compounds have, little by little, been moving downstream with suspended particulate material and become diluted so close to background levels that they cannot be detected in the sediments or fish in the delta region of the Athabasca River. If they can be detected with high resolution analytical methods, it is unlikely that there is any significant difference between dioxin and furan concentrations in the delta and in natural reference areas.

The aquatic chemistry, particularly the dissolved oxygen (DO) content of the Athabasca River upstream of the Grand Rapids, was reviewed. Assuming that the mills will meet the requirements included in their operating licenses, the situation with BOD_5, chemical oxygen demand (COD), AOX and DO will not essentially change from 1990 to 1993. This is due to more efficient water pollution control and the improved technology at the Weldwood mill in Hinton. If the ALPAC mill is built, the loadings of the above-mentioned impurities will increase slightly when ALPAC is running at full capacity. The effects on DO concentrations in the Athabasca River would be significantly restricted to an about 200 km long area in the middle of the river (Athabasca City-Grand Rapids). The lowest DO content of the river water without ALPAC would be about 6 mg O_2/l. With the proposed ALPAC mill it would be between 5-6 mg/l, which would not be limiting the survival of adult fish in this area. Since the major spawning areas for fall-spawners are believed to be either far up- or downstream, the most sensitive eggs and larvae would not be exposed to the decreased DO levels. The DO content would be 6-9 mg/l elsewhere in the Athabasca River, and it would not be significantly influenced by the proposed ALPAC pulp mill. It is obvious that the oxygen conditions would not be a problem during snow melting and open water seasons and spring-spawning fish would not be affected by low DO conditions.

The phosphorous and nitrogen discharges from the pulp mills were estimated and the total phosphorus loading was compared to the overall phosphorus loading of Lake Athabasca. The phosphorous loading from the pulp mills does not have a major contribution to the annual phosphorus loading. However, it is expected that a considerable part of the P-loading is not biologically available for algae. This fact should of course be confirmed and, if incorrect, some additional requirements to limit the quantity of phosphorous in the effluent should be set on the pulp mills along

the Athabasca River. As neither phosphorous nor nitrogen stands out as the main limiting factor for the algae production of the lake, some additional research could also be carried out to assess the effects of these nutrients.

Information on the population of fish, their spatial distribution, migrations and commercial importance in the Athabasca and Peace River watersheds is limited although some data were provided to the original review and are included in this report. In the study area between Athabasca and the Grand Rapids the information seemed to be extremely limited, however, Alberta Environment reviewed the existing baseline data with the study team which allowed the team to make some preliminary statements, as well as a few recommendations for further studies.

In the Athabasca River System commercial fishing is restricted to the river delta, and in particular, to the Lake Athabasca. Recreational fishing is currently being practised mainly in the Athabasca River from Hinton upstream and in the tributaries. Little is known about current recreational fishing habits in the reach between Whitecourt and Grand Rapids. More information is also needed with respect to not only about the extent of recreational fishing in that area, but also about fish tainting, in at least the immediate vicinity of the present pulp mills, as well as in the reach between Fort McMurray and Lake Athabasca. Other sources of contamination should also be taken into account. A dioxin and furan survey in fish from the neighbourhood of the kraft pulp mills is a logical start, and actually some 80 fish caught a few kilometres downstream of Hinton and Grande Prairie are now being analyzed by the Department of Fisheries and Oceans in Ottawa. This work should be extended in the near future also to areas further from the mills and to reference areas which have not seen any pulp mill effluent.

According to results from fish physiological studies performed throughout the world, chlorinated phenols, guaiacols and catechols are excreted from fish within areas under continuous or intermittent exposure and the above-mentioned compounds do not bioaccumulate to the same extent as some other well-known chlorinated organic compounds (DDT, PCB). The half-lives of chlorinated dioxins and furans in fish are much longer and these bioaccumulate strongly. Migration of fish and variations in the concentrations of the above mentioned chemical impurities play a vital role in the bioaccumulation and transport of dioxins and furans across territorial waters. It is recommended that future analysis be made from relatively old fish in order to have as conservative an estimate as possible for assessments of human risks. Such analyses can also reflect any bioconcentration caused by the emissions during the past 30 years. These samples should at least be taken from the spawning areas below the Grand Rapids as well as from older fish from the reach between Hinton and the Grand Rapids.

There are no anticipated toxicological risks to the human population caused by the discharge of chlorinated substances from pulp mills into nearby waterbodies in the study area. In addition, published information from the literature review showed that inhabitants of the Lake Athabasca area and the Wood Buffalo Park consume less fish than was initially estimated.

2

PULP MILLS ON ATHABASCA AND PEACE RIVER WATERSHEDS

In Alberta only two pulp mills were in operation before 1988, i.e. the kraft pulp mill at Hinton now owned by Weldwood and the Procter & Gamble kraft pulp mill at Grande Prairie. In British Columbia by the Peace River there were also two mills in operation before 1988, the Fletcher Challenge kraft mill at MacKenzie and the Finlay mill also at MacKenzie making mechanical pulp. These mills are shown on the map in Figure 2/1.

Figure 2/1 also shows the recently built mills that have been started up since 1988. In 1990 three mills are to be started up, i.e. the Alberta Newsprint CTMP-mill at Whitecourt, the Alberta Energy Co. CTMP-mill at the Town of Slave Lake, and the Daishowa bleached kraft pulp mill at the Town of Peace River.

Recently a major reconstruction and an expansion to a doubled capacity have also taken place at the Hinton mill. This expanded unit has also been taken into operation in 1990.

The proposed mill by Alberta-Pacific Forest Industries Inc. would be started in 1993. Procter & Gamble have also indicated plans for a reconstruction and expansion of their Grande Prairie mill by 1993.

The rapid expansion of pulping capacity along the Peace and the Athabasca watersheds is illustrated by Figure 2/2 showing the nominal pulp production capacities for the period 1987-1993.

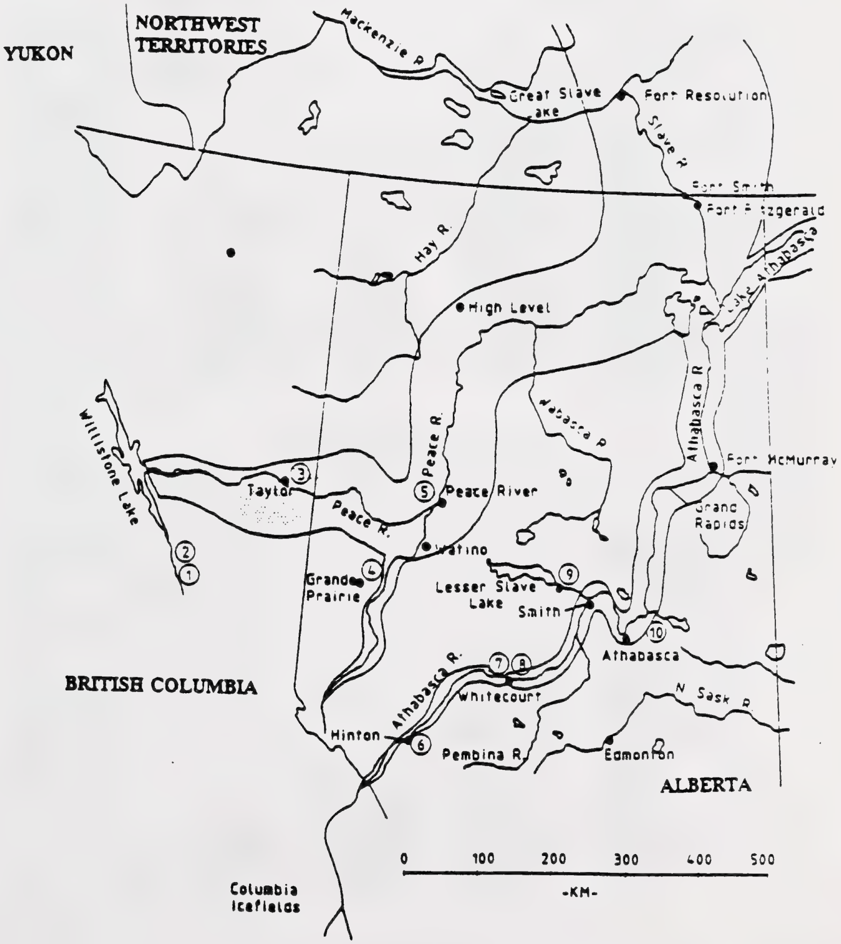
3

WATER POLLUTION FROM THE PULP MILLS

From an environmental point of view there are a number of differences between a chemical pulping operation (like kraft pulping) with a bleach plant and a mechanical pulping operation (like ground wood, TMP and CTMP manufacturing).

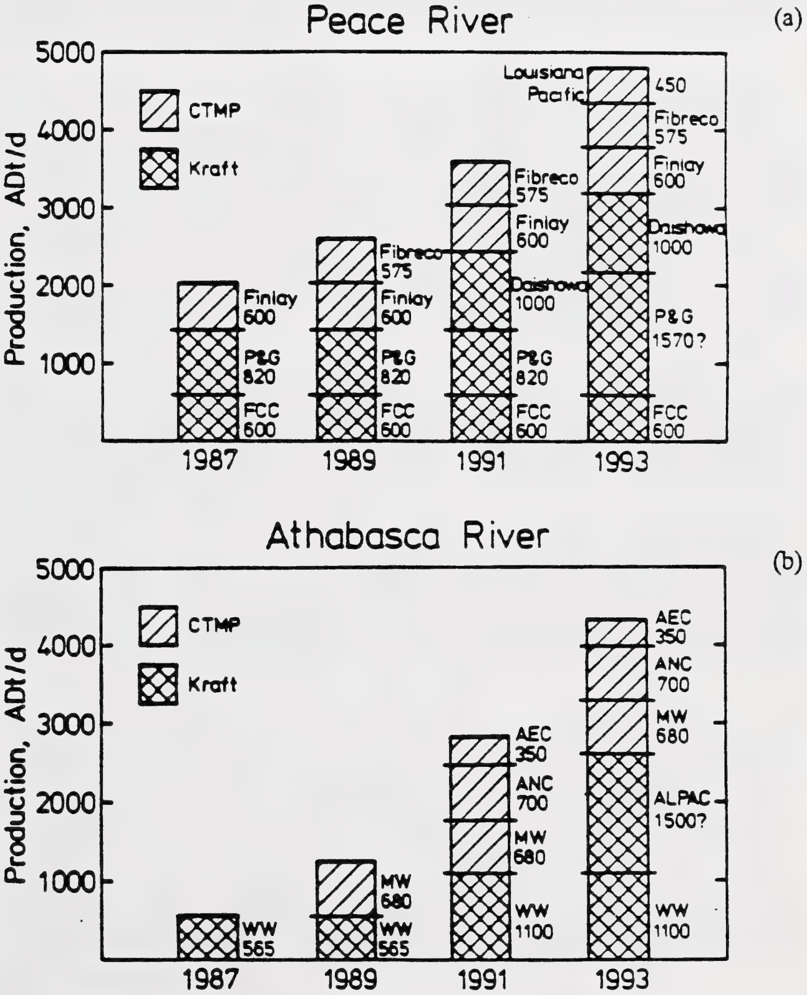
Emissions from mechanical pulping are all "wood-like" in the sense that they come from the wood in a relatively unmodified way. Emissions to the atmosphere may consist of terpene compounds, while emissions to water include extractable compounds as well as polymeric substances, primarily hemicelluloses. Some substituents that are easily split off from lignin and hemicelluloses (like methoxyl and acetyl groups) may also be released causing an impact on the environment.

FIGURE 2/1
Pulp Mills in the Study Area



1 Fletcher Challenge
2 Finlay Forest Ind.
3 Fibreco
4 Procter & Gamble
5 Daishowa
6 Weldwood
7 Alberta Newsprint
8 Millar-Western
9 Alberta Energy
10 Alberta-Pacific

FIGURE 2/2
Pulp Production Data for Pulp Mills Along the Peace and the Athabasca Rivers in british Columbia and Alberta. (a) Peace River. (b) Athabasca River



Various compounds in the emissions from these mills are readily degradable in nature thereby causing a biochemical oxygen demand. Some of the compounds released may be more or less toxic (like some of the extractable compounds) before they are degraded.

The mechanical pulping operations also release some suspended solids primarily being wood components like fibres and perhaps some bark residues.

When bleaching of the mechanical pulp with peroxide and/or dithionite it is the usual practice to add some chelating agent before the bleaching. The purpose of this chelating agent is to reduce the negative impact of some metallic ions in trace quantities on the bleaching result. The chelating agent is discharged with the effluent after the processes. Because of the ability of chelating agents to bond to metallic ions and keeping these ions in solution, there is a concern that the chelating agents may cause dissolution of heavy metal ions from sediments. Therefore the mills are often restricted in their use of these agents.

If the mills practise biological treatment of the effluent, nutrients – mostly phosphorus and nitrogen – have to be added to improve the microbial growth. A part of these nutrients will be discharged to the receiving waters contributing to the eutrophication.

In conclusion, the mechanical pulp mills are usually restricted in their discharge of suspended solids (TSS), biochemically degradable matter (BOD), and also COD (chemical oxygen demand) and TOC (total organic carbon)), resin acids, pH, nitrogen, phosphorus and colour. Limits are also usually applied for the toxicity of the effluents.

Emissions from bleached kraft pulp mills are more complex. This is due to the chemical changes that take place during the processes. The emissions to the atmosphere consist of compounds used for the actual processes (like chlorine and chlorine dioxide and even hydrogen sulphide), compounds released and originating from the wood (like extractable compounds and methanol), compounds being formed between the wood and the added chemicals (like the odorous compounds), or matter being formed and released in the recovery processes (like sulphur dioxide, hydrogen sulphide and particulate matter).

Emissions discharged with the effluents are essentially those from the bleach plant, but other sources like accidental spills from the caustisizing area, and pulp drying (or paper) machine section also contribute somewhat to the environmental impact. As for the effluents from mechanical pulping operations the ones from kraft mills are characterized by BOD, COD, suspended solids, and so on.

However, in addition to those conventional measures of the effluent characteristics the chlorinated substances that are formed in the bleach plants have caused a major concern. These compounds are often grouped together as adsorbable chlorinated organic compounds termed AOX. During the eighties substantial research has been undertaken in order to identify these compounds through new analytical techniques and to make a judgement of their environmental impacts. At the same time extensive efforts have been spent on modifying the pulping processes to reduce the negative impact of the effluents.

Among all the chlorinated substances discovered those regarded as being the most harmful ones are the polychlorinated (especially tri- and tetrachlorinated) low-molecular weight compounds. This is because these substances are toxic and have a high affinity to organic tissues and some of them may even be bioaccumulating.

Among the discovered compounds there are some chlorinated dibenzodioxins and dibenzofurans that have caused special concern. This concern is due to the fact that these compounds are believed to be harmful to fish consumers, including man.

The recent process developments that have taken place in the pulp bleaching field have been focused on reducing the formation of these harmful substances. As a result a number of new techniques have become available that can reduce the amount of chlorinated substances by 5 to 10 times. In addition to that, the new processes reduce the amount of those compounds being regarded as the most harmful ones (poly-chlorinated compounds) many times more than that. For instance with modern technology the tetrachlorinated dioxins and furans cannot be detected with present analytical procedures.

Thus, the collective measure of chlorinated organic substances (AOX) overestimates the negative impact of the effluents and more specific analyses have to be taken into consideration when making an impact assessment.

Figure 3/1 shows the estimated discharges of AOX from the pulp mills along the Peace and Athabasca Rivers for 1987, 1990 and 1993. This period of time is of special interest because substantial expansions are (planned or) taking place along the two rivers. Simultaneously, there is an important technological change going on in the mills in order to reduce the environmental impact of bleach plant effluents.

FIGURE 3/1
Estimated discharges of chlorinated organic compounds (measured as AOX) to the Peace and Athabasca Rivers from pulp mills. Column 1993 a refers to full expansion by Procter & Gamble with 1.5 kg AOX/Adt being discharged and with ALPAC at 1.3 kg AOX/Adt; 1993b refers to full expansion by Procter & Gamble and by ALPAC with best available (and practical) technology discharging 0.7 kg AOX/Adt for all new capacity; 1993c refers to a case with no further expansion (neither by Procter & Gamble nor by ALPAC).

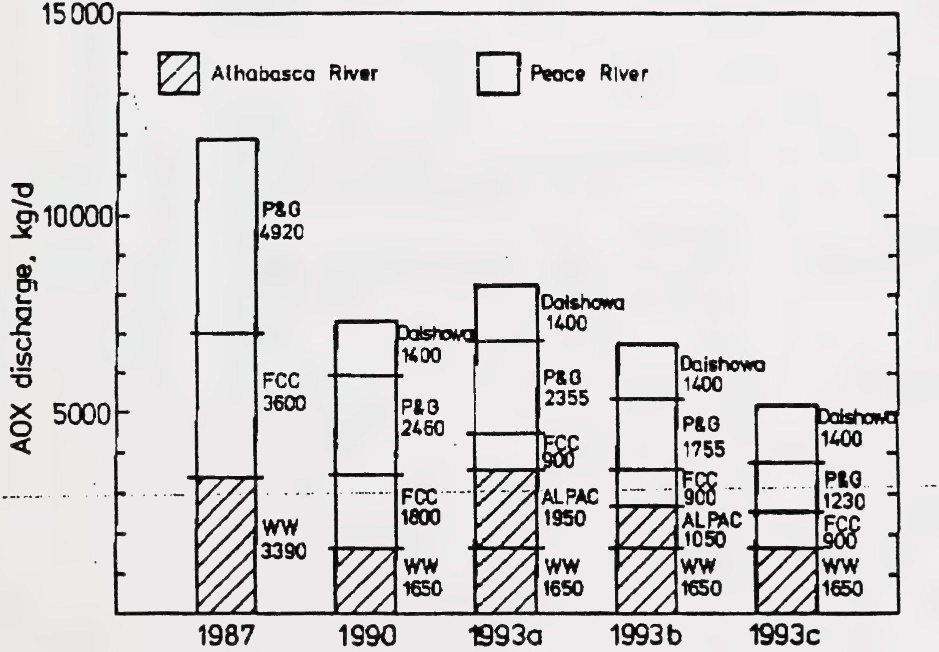


TABLE 3-1
Estimated Pulp Mill Effluent Discharges into the Athabasca River in 1993 Used in Water Quality Estimates (from Alberta Environment 1990b and ALPAC 1989a)

	Production Adt/d	BOD5 kg/Adt	TSS kg/Adt	TOT.P * g/Adt
Weldwood	1100	3.0	NE	55
Millar Western	680	3.0	5.0	90
Alberta Newsprint Co.	700	3.0	5.0	55
Alberta Energy Co.	350	3.0	5.0	90
ALPAC **	1500	1.5	3.0	60

NE = not established
* = expected load (Alberta Environment 1989)
** = proposed and estimated values

Other parameters than AOX may also be of interest. The anticipated loading to the Athabasca River is shown in Table 3-1.

4
ENVIRONMENTAL IMPACTS IN ALBERTA

4.1
Introduction

The environmental impacts of the proposed ALPAC pulp mill are expected to be limited mainly to the province of Alberta. Possible additional effects in NWT are discussed in Chapter 5.

Perhaps the most difficult part of the work was the assessment of the effects of chlorinated organic compounds. It is widely known that many of these compounds have adverse effects on the aquatic ecosystem. However, the long-term risk assessment of certain specific compounds should be based on tests regarding lowest observed effect level (LOEL). They are not available for most chlorinated organic compounds identified in bleached kraft pulp effluents. It seems that the less toxic a compound is (but still toxic), the more work and time it takes to assess the risks in the individual organisms and in the food chain. Extremely toxic compounds have clear effects already in the first LC_{50} and other acute toxicity tests at an early stage.

4.2
Predicted Oxygen Concentrations in the Athabasca River

When the Athabasca River is not covered by ice the high reaeration rate is sufficient to keep dissolved oxygen in the water at well above critical values in all the development scenarios presented for the forest industry along the river. Low flow and almost complete ice cover prevents reaeration during winter for most of the Athabasca River. This makes it very vulnerable to oxygen depletion due to organic load discharges during late winter.

The hydrological data base of the dissolved oxygen (DO) model application to the Athabasca River is extensive and DO/BOD data collected during winter 1989 surveys is sufficient to calibrate the model in near-7Q10 flow conditions. 7Q10 means the lowest average 7 days' flow occurring once in 10 years. Because ice cover prevents reaeration in winter, the dissolved oxygen level in water entering the mill site is dictated by the upstream consumption. To clearly compare different BOD load scenarios for ALPAC, the winter 7Q10 flow rate at Athabasca was chosen as the hydraulic basis. This flow rate provides the least dilution downstream from the ALPAC mill site and will therefore be called the worst case flow condition. It should be emphasised that the average winter low flow is substantially higher than the 7Q10 flow. In order to differentiate the impact of the ALPAC mill from that of the other four mills (Weldwood, Alberta Newsprint, Millar Western and Alberta Energy) three scenarios were calculated (see Figures 4/1 and 4/2):

The results of the scenarios are as follows:

1. No Mills

- Without any mill loadings, the DO will decline gradually from Hinton to the Grand Rapids, to the level of 8–9 mg/l (upper curve in Figure 4/1).

2. Four mills currently existing or being constructed at 3 kg/ADt BOD load rate (no emissions from ALPAC)

- If the four mills are releasing BOD at 3 kg/ADt the organic load from the upstream mills is largely decomposed or sedimented out before reaching ALPAC and the DO level will decline to a minimum around reach #23 where some reaeration occurs. There is a small decline of about 1 mg/l between reach #23 and the ALPAC site. DO will reach a minimum of 6 mg/l at the ALPAC mill site and stay at this level until reaching the Grand Rapids. At the Grand Rapids reaeration causes a sharp immediate increase in DO by about 4.5 mg/l in all calculated scenarios (Figure 4/1).

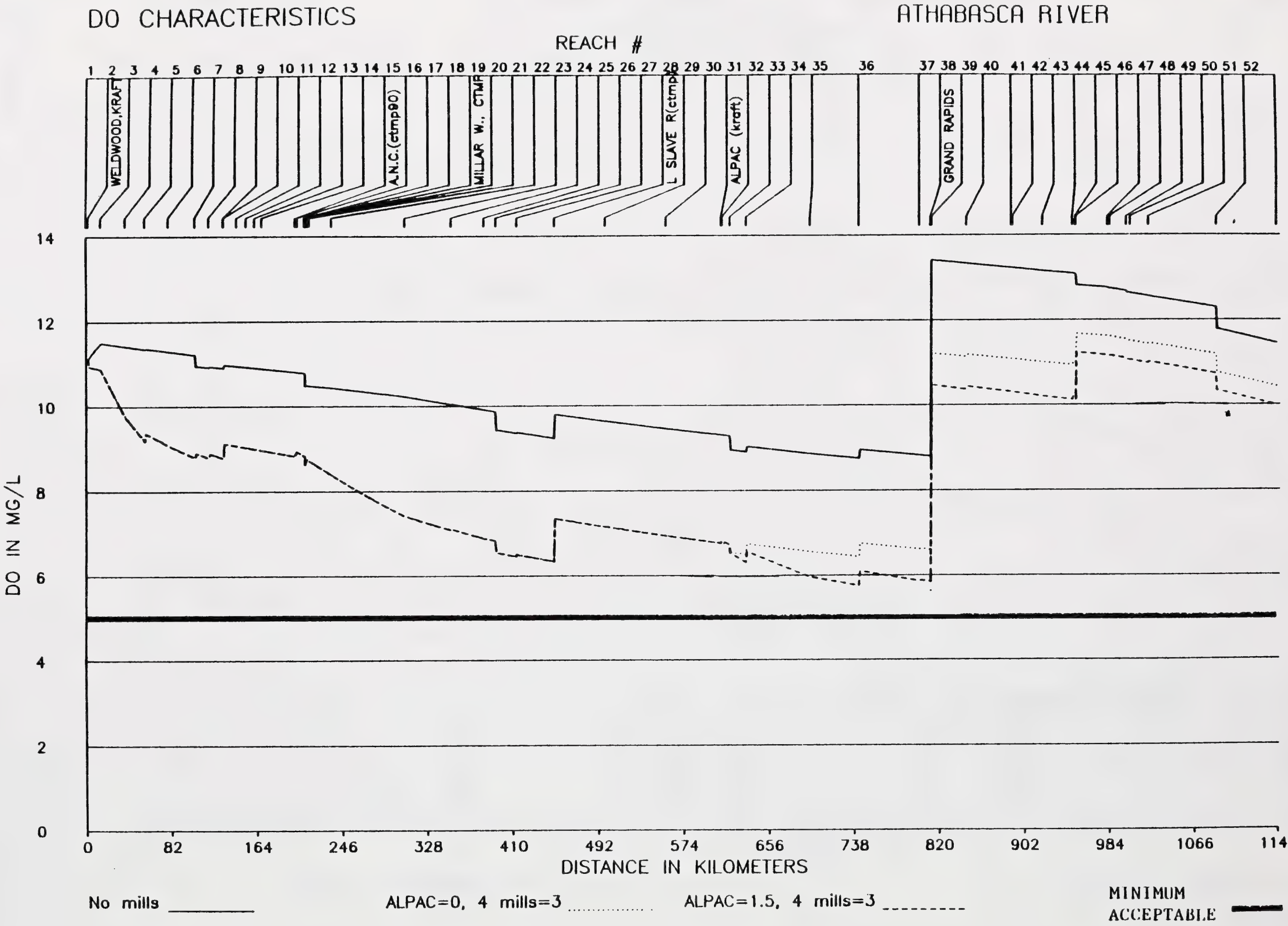
3. ALPAC BOD at 1.5 kg/ADt and the other four mills BOD at 3 kg/ADt

This is the most important scenario.

- The additional BOD–load of 1.5 kg/ADt from ALPAC will result in an additional drop of approximately 1 mg/l until reaching the Grand Rapids. The DO remains slightly above 5.0 mg/l (Figure 4/1). After the reareation the DO is above 9 mg/l all the way to the Lake Athabasca.

The DO calculations are also modelled to a more frequent low flow condition 7Q2. 7Q2 means the lowest average 7 days' flow occuring once in 2 years. The recalculated 7Q2 is somewhat conservative and gives DO–values that are too low rather than too high. The results shown in Figure 4/2 are similar to these for 7Q10 flow except that the dissolved oxygen values average 1 mg/l higher, both with and without ALPAC.

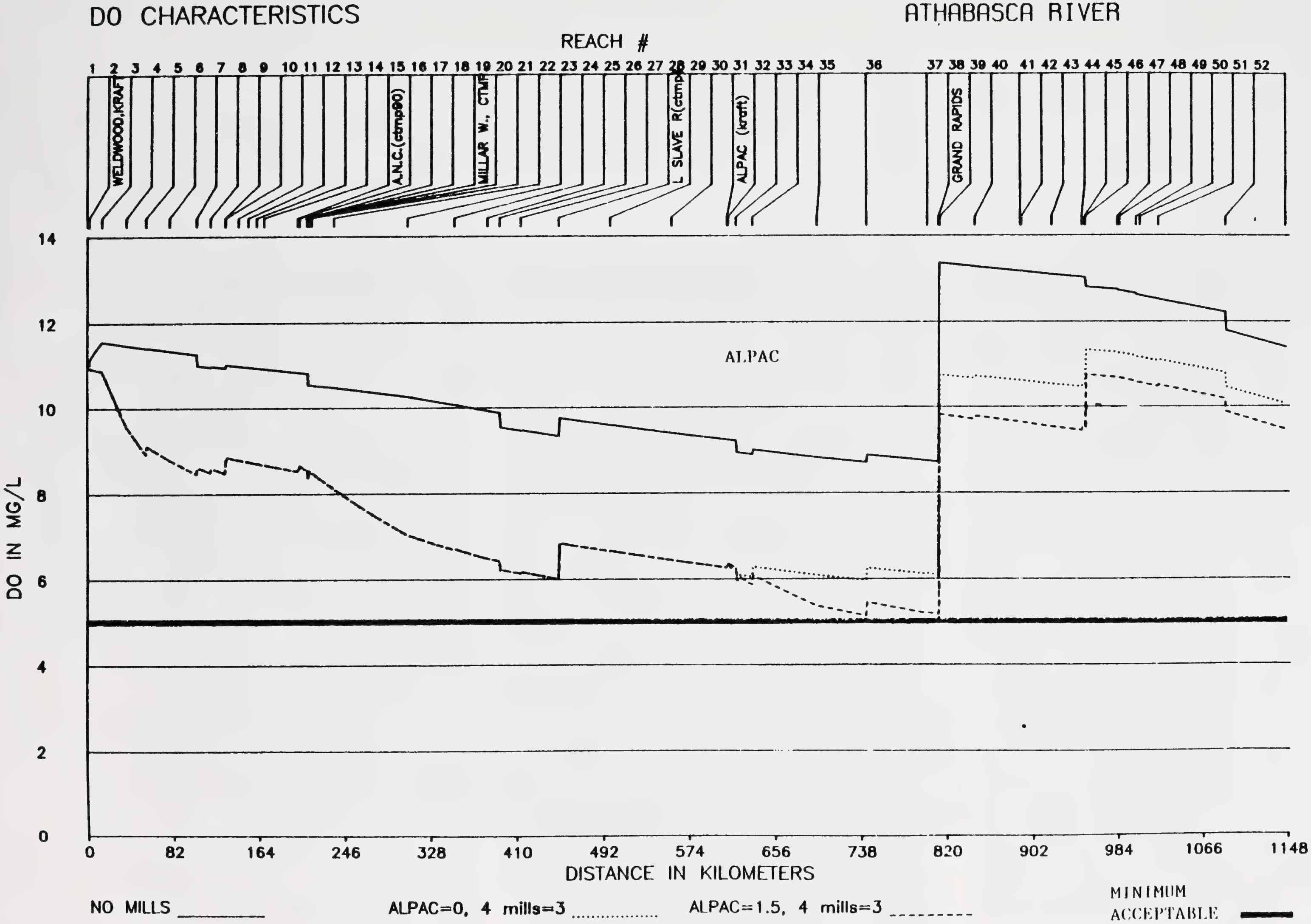
Figure 4/2



SCENARIOS at ATHABASCA 7Q2 flow conditions (FPPRI)

Alberta Environment

Figure 4/1



SCENARIOS at ATHABASCA 7Q10 flow conditions (EPPRI) Alberta Environment

4.3
Impact of Dissolved Oxygen on Fish

Dissolved oxygen (DO) is required by aquatic organisms for aerobic respiration. At low concentrations, it can become a limiting factor for maintenance of aquatic life. The lower lethal limit is species-specific. The effects of toxicants may be magnified, if the aquatic organism is under stress due to low dissolved oxygen. There are a number of surface water quality guidelines and objectives for dissolved oxygen. The current Alberta water quality objective (ASWQO) is 5 mg/l. However, this standard is now under review and will possibly be replaced with a higher value of 6.5 mg/l. Current Canadian federal water quality guidelines (CWQG) are 9.5 mg/l for sensitive salmonoid species and lifestages.

The dissolved oxygen concentrations in the Athabasca River and the modelling of it has been dealt with in section 4.2 of this report. According to studies made by Alberta Environment (Noton and Shaw 1989) the DO concentration in the Athabasca River was decreasing from the point at Whitecourt and reached a minimum of about 5.5 mg/l within Lesser Slave River confluence. According to the dissolved oxygen model calculation for this report, the DO concentration could decrease to close to 5 mg/l when ALPAC and the other mills planned are in operation at maximum capacity. The DO level should not drop below 5 mg/l if all of the mills operate within their licensed effluent release limits (see Figures 4/1 and 4/2). Furthermore, provision has been made in the mill operating licenses for a reduction in the BOD releases for conditions of low river flow, or when DO-levels could fall below the ASWQO minimum. The low oxygen level will extend from the proposed ALPAC mill site to Grand Rapids and will cause impacts to aquatic life in that reach. After Grand Rapids the DO concentration will increase to a level of approximately above 9 mg/l even during low flow conditions with all proposed mills in operation.

Fish spawning and the early lifestages of fish are considered to be the most sensitive to low DO concentrations. The known spawning areas in the Athabasca River are situated downstream from Grand Rapids where DO concentrations, even during low winter flow conditions, are above 9 mg/l. This means that dissolved oxygen is not a problem for species breeding in areas between Grand Rapids and Lake Athabasca. No spawning areas have so far been identified between Grand Rapids and the proposed ALPAC mill site, and even further upstream to Hinton. The DO concentrations in this area are expected to decrease to between 6 to 8 mg/l after construction of the ALPAC mill and will further decrease to about 5 mg/l for 7Q10 flow conditions. According to the model, the DO concentrations will drop to 8 mg/l even when no mills are operating. Thus, the successful breeding of the most sensitive salmonoid species is in any case doubtful in this part of the river.

The DO demand differs for different fish species, and depends on their breeding habitats. The breeding grounds and the sediment oxygen demand must also be considered when the sensitivity to water DO concentrations are discussed. At present the fish species living in the Athabasca River have to breed either in the mainstem or in the tributaries in order to maintain their stocks. The breeding areas and the breeding migrations in river reaches with low oxygen levels have not been studied, and it is felt that a major investigation is warranted. It is quite obvious that once all proposed mills are operating DO concentrations during low winter flows in the Athabasca River will be of concern. The present lack of information precludes a proper impact assessment in relation to this matter.

4.4
Sediment Transport and Sedimentation

The Athabasca River transports large amounts of suspended material which subsequently settles and forms deltas and lake sediment, further down the river system. The elevation of the land, following passage of the last glacier, has caused the river to scour and cut through a filled pre-glacial valley. The suspended material at this point along the river consists mainly of glacial lake deposited silt and clay, as well as finer till material. There is a smaller amount of suspended organic substances originating from biological activity in the catchment and in the river. Close to the river bed, coarser material is transported, such as gravel and stones. The Upper Athabasca River has been called a "wandering gravel river".

Further downstream, the slope of the river decreases (from >0.01 % to 0.003 %) and the river becomes less incised. By Embarras the river no longer flows in a typical valley; rather, it begins meandering over a wide flood-plain to the delta at Lake Athabasca. The river bed in the lower part of the Athabasca is static and consists of large gravel and rocks, covered by a moving bed comprising mostly fine sand and local gravel. By comparison, with the analogy made in the preceeding paragraph, the lower Athabasca River can be called a "wandering sand river". Contrary to the general trend found in most rivers, the size of the moving bed material increases in the lower part from Fort McMurray to Embarras, as the amount of clay in the sand decreases. This probably reflects the local river bank material which has been eroded.

The Athabasca River empties through several channels into a large delta on the southwestern side of Lake Athabasca. There are four major channels in the delta; however, two of these (Goose Island Channel and Big Point Channel) discharge more than 70 % of the river water(Figure 4/3). During high flow, the delta is more or less flooded. During extreme low flow events water currents can only be detected in Big Point Channel. From Lake Athabasca, the Athabasca River water, mixed with lake water, meets the Peace River to form the Slave River. The hydraulics in the south-western

part of Lake Athabasca are very complex, and the mixing of the river water in the outflow from the lake depends on discharges, winds, water currents, ice conditions, etc. A mean annual water balance for this area is shown in Figure 4/4, according to this estimate the Athabasca River accounts for about 50 % of the outflow of Lake Athabasca.

An important question in the context of this study is, how much of the sediment load in the Athabasca River is deposited in Lake Athabasca, and how much is transported further downstream to the Slave River.

FIGURE 4/3
Calculated Expansion of Inflow Jets in
Lake Athabasca. From Neill et al. (1981)

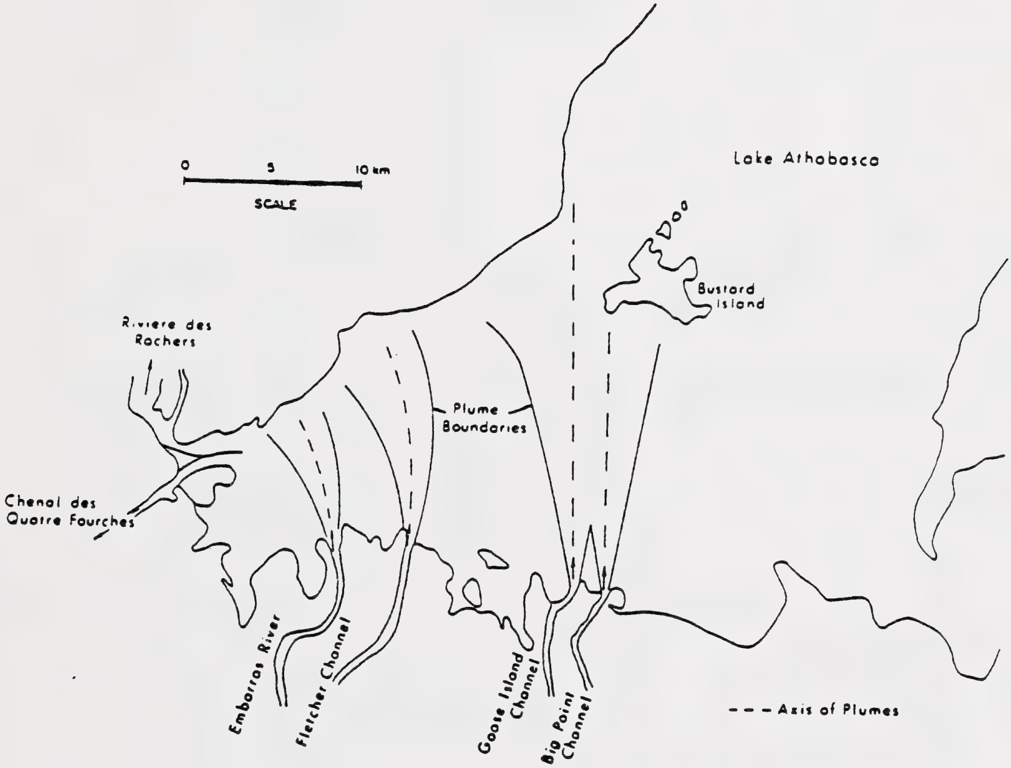
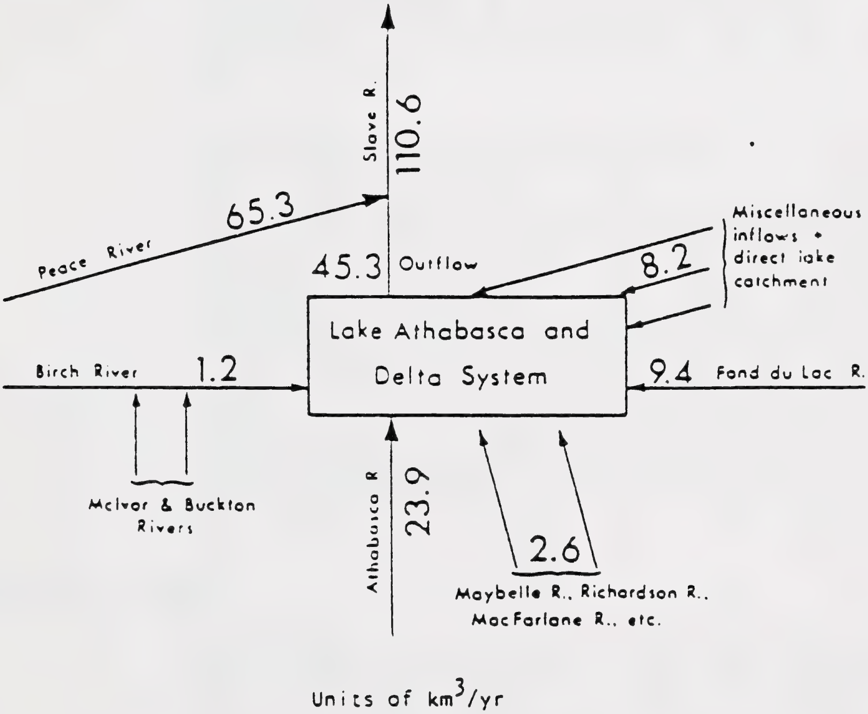


FIGURE 4/4
- Mean Annual Water Balance, km³/year, of the
Lake Athabasca System. From Neill et al. (1981)



There are data available on suspended sediment loads in the Athabasca River from 1969 to 1977. During this period, the range of sediment loads to Lake Athabasca was 3.3 to 12.9 million tonnes/year, with an average of 7.5 million t/year (the data were recorded at Fort McMurray over a five-month period, May through September, but no significant transport was believed to occur during the rest of the year). Roughly one half of the annual sediment transport occurred during one month, usually June, July or August, and about 10 % of the annual transport often occurred during one day.

Based on the analysis of limited sediment data for 1973, 1975 and 1976, it was estimated that about 65 % (range 55–79 %) of the sediment inflow from the Athabasca River passes through to the Slave River via Rivière des Rochers. These values were also checked with grain size distributions which gave results in reasonable agreement with those listed above. The portion passing through consisted mainly of fine to medium silt plus clay, while coarse silt and sand were believed to be deposited in the Athabasca Delta channels or at the delta front in Lake Athabasca. These figures would seem to indicate that the Athabasca Delta is expanding in area by about 0.8 km^2 per year, which appeared to be confirmed by satellite images and earlier aerial photographs. The somewhat controversial scientific information available indicates that a significant if not a major part of the sediment load of the Athabasca River is deposited in the lake instead of passing through.

4.5
Fish Ecology and Fisheries

The fish ecology is not well known throughout the reaches and tributaries of the Athabasca River above the Grand Rapids. This is especially true for the reaches immediately downstream of the proposed ALPAC pulp mill to the Grand Rapids. However, much more is known about the fish and their habitat requirements downstream of the Grand Rapids and in the delta.

The mainstem of the Athabasca River, from the community of Fort Assiniboine to the Grand Rapids, is the least known section of the entire Athabasca Basin. By contrast major studies have been conducted, in the reach from the Grand Rapids to Fort McMurray and downstream to the delta and Lake Athabasca. The Athabasca mainstem above and below Cascade Rapids serves as a major spawning area for several species of fish, including populations of lake whitefish, which reside in Lake Athabasca and migrate upstream during the summer (Figure 4/5). These fish spawn in the fall, in the vicinity of Mountain and Cascade Rapids, upstream of Fort McMurray. It has been estimated that a minimum of 300,000 and a possible maximum of over a million lake whitefish spawn in this area. The river spawning population is a relatively fast-growing one, lives to the age of about 20 years; thus differing from the lake spawning population which grows more slowly but lives longer. The Athabasca River below the Grand Rapids is

also known as a spawning area for longnose sucker, walleye and possibly trout perch.

Fish migrations and overwintering sites of different fish species are also known from the area between Grand Rapids and Lake Athabasca and the delta. As to other parts of the Athabasca River there is some knowledge of the existing fish species in the mainstem and tributaries.

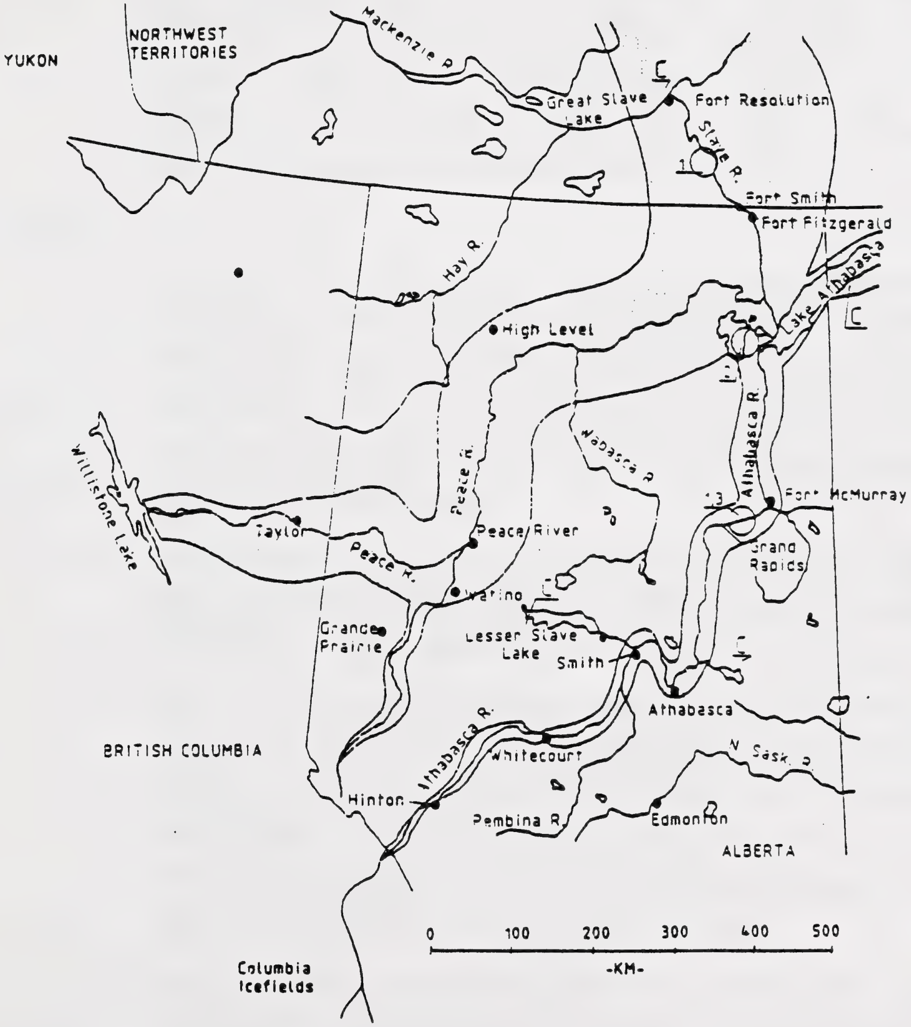
There are few, if any, studies of fish migrations between the mainstem and the tributaries of the Athabasca River. Fish reproduction areas and overwintering areas in the Athabasca River and its tributaries, excluding areas downstream of the Grand Rapids, are not known.

Twenty–five fish species have been identified in the Slave River. Most of these species are found in the area which extends from the Slave Delta upstream as far as the Rapids of Drowned at Fort Smith. The rapids apparently presented a barrier to upstream movement. The most abundant fish species as a whole in the Slave River, (excluding the smaller fish species) is goldeye, followed by lake ciscoe and northern pike. Lake whitefish and other autumn–spawning species, like inconnu, enter the Slave River in late summer and breed beneath the rapids. After spawning they return to the Great Slave Lake. The model is very similar to the breeding behaviour of autumn–spawning fish from Lade Athabasca.

The impact of the future ALPAC pulp mill such as a potential loss of fish habitat and fish production capacity, as well as effects on fisheries, cannot be determined due to lack of information on baseline fish populations and critical fish habitat in the Athabasca River mainstem and tributaries. This is especially true for the area between the proposed mill site and the Grand Rapids. The known breeding areas below the Grand Rapids are situated about 200 km downstream of the proposed mill site. When considering the 7Q10 flow of 53.6 m^3/s at Athabasca and the proposed effluent flow of 0.95 m^3/s, the concentration of effluent close to the outlet will be about 1.7 %. The effluent concentration will then be diluted to concentrations below 1 % upon reaching the breeding areas.

Freshly fertilized rainbow trout eggs, placed in solutions containing 5.6 to 100 % biologically treated bleach kraft mill effluent (BKME), developed in a fashion similar to the control eggs when the effluent concentration was less than 32 %. Artificial stream studies have not shown any deleterious effects on warmwater and coldwater fish production or reproduction in biologically–treated BKME at typical dilutions. However, effluents from a pulp and paper mill, with conventional bleaching and an external effluent treatment in an aerated lagoon, were shown to affect northern pike eggs in concentrations of as low as 0.5 %. Here it should be kept in mind that conventional bleaching produces 5–8 kg AOX/ADt, in contract to the proposed ALPAC mill producing 1.3 or 0.6 kg AOX/ADt.

FIGURE 4/5
Areas with Commercial Fishing and Known Fish Spawning and Migration Areas (from Wallace and McCart, 1984)



C = areas with commercial fishing

1. Known spawning area of lake whitefish, lognose sucker and probably walleye
2. Probable spawning area of goldeye
3. Lake whitefish and walleye are known to migrate to this area; northern pike is known to spawn in tributaries.

Northern pike from the Athabasca Basin are known to spawn in marshy areas adjacent to the river and in some tributaries. Spawning is thought to occur in late April and early May. The flow of the Athabasca River has increased considerably from the winter lows during that time as has the dilution of the ALPAC effluent. This means that the effluent from the proposed ALPAC pulp mill with oxygen prebleaching and activated sludge effluent treatment is likely to have no effect on the development and survival of pike eggs or any other fish eggs in the known spawning areas. Spawning in these areas is occurring during periods other than those with critically low flow conditions. This means that the sensitive stages of reproduction (fertilization and hatching) take place when the effluent concentration downstream of the Grand Rapids is far below 1 %.

Fisheries

The pressure of urban, agricultural and industrial growth has already taken its toll on the fish habitat and fish populations of the region. The Athabasca Basin provides sport fishing opportunities for almost 9 % of Alberta's licensed anglers. The mainstem of the Athabasca and tributary rivers, such as the Berland, McLeod, Pembina and Clearwater, supply important, and in many cases well-utilized sport fishing opportunities. In the reaches below the proposed pulp mill sport fishing is mainly concentrated in the tributaries, with very little in the mainstem.

Among sportfish, Arctic grayling, northern pike, yellow perch and walleye are the most widely distributed in tributary streams. Lake whitefish, which is an important domestic fish, is widely distributed, but generally restricted to confluences along the Athabasca River.

The commercial fishing is concentrated in Lesser Slave Lake and Lake Lac La Biche. The areas for commercial fishing and major spawning areas are shown in Figure 4/5. The range from coldwater to warmwater fish habitat, which occurs throughout the Lesser Slave Sub-Basin, results in a diverse fish population. The Lesser Slave Lake fishery is the oldest and most productive commercial fishery in the Athabasca Basin. Lac La Biche is one of the most important commercial fisheries in the entire Athabasca Basin, and one which has been exploited for well over 40 years.

The species fished commercially in Lesser Slave Lake and Lake Lac La Biche are mainly lake whitefish, walleye, pike and lake trout. These species are known to spawn mainly in the tributaries of the lakes and there is little or no evidence of large fish migrations between the lakes and the mainstem of Athabasca River. According to Wallace and McCart growth of lake white fish in Lac La Biche is similar to that reported for Cold Lake and Lesser Slave Lake. The lake whitefish inhabit deeper water and will move to shallower reaches with sand-gravel substrates to spawn. Walleye, which also frequent the deeper waters of the lake, move into shallower areas and

inlet creeks to spawn at night. The weedy embayments and adjacent sloughs are used by pike for spawning, as are some sand-gravel lake edge areas by whitefish. The precise locations are poorly defined at present and there is little or no evidence of large fish migrations between the lakes and the mainstem of Athabasca River. As there is no evidence of migration of the commercial fish populations from the lakes to the Athabasca River the commercial fish stocks will not be exposed to pulp mill effluents.

Domestic fishery in the Slave River is very selective, and in catches, lake whitefish is the most abundant, followed by burbot and inconnu. There is a large commercial fishing industry in Great Slave Lake. This commercial fishery is the only one with a significant export component. According to information from the Department of Fisheries and Oceans (1988) five species are exported, of which lake whitefish is most abundant, followed in order by lake trout, northern pike, inconnu and walleye. Sport fishing in the Slave River is of minor importance compared to the Athabasca River.

Commercial fish populations in Lake Athabasca and Great Slave Lake are not at risk from the pulp mill related toxicants because of the great dilution factor and the degradation of toxicants before reaching the lakes.

4.6
Effects of Chlorinated Organic Compounds

Introduction

One of the most important tasks of the Complementary Review was to provide additional scientific information on the possible ecotoxicological impacts of the ALPAC project. In the risk assessment one should always make clear distinction between the facts and the hypotheses. The highly toxic effects of 2,3,7,8-TCDD on the Guinea pig and Sprague-Dawley rat is a fact but high toxicity on human beings is a hypothesis. The 2,3,7,8-TCDD is much less toxic to other mammals (like hamster and rhesus ape) than the above-mentioned sensitive animals.

The potential deleterious environmental impact of chlorinated organics, particularly the dioxins and furans formed in the bleaching process, was discussed in the March, 1990 Report of the EIA Review Board. The toxic effects of several individual compounds in pulp mill effluents is well documented. However, the synergistic and anthagonistic effects and the contribution of the identified toxic compounds on the effluent overall toxicity is less well understood.

Transport and Distribution

Investigations of the environmental transport and distribution of specific contaminants discharged from pulp mills using conventional chlorine bleaching, have mostly been devoted to the study of polychlorinated phenolics and dibenzo-p-dioxins and furans. It has generally been assumed that the sorption behavior of these compounds to sediment particles is closely governed by their degree of hydrophobicity, i.e., their partition coefficient between n-octanol and water (P_{ow}). Sorption of a compound to the sediment phase will result in rapid removal of the chemical from the water phase. In some cases, however, the sediment sorption behaviour of a chemical cannot be properly predicted from the P_{ow}, normally used in the initial assessment. One example is the polychlorinated catechols, which are quite tightly bound to the sediment phase – in fact, so strongly that they cannot be recovered by simple solvent extraction. Thus the strong sediment-binding properties of clorinated organic compounds is an important factor in their transport and bioavailability to various organisms.

Most of the chlorinated organic compounds in pulp mill effluents will rapidly become associated with suspended particles. In order to predict the fate of these contaminants from the planned ALPAC mill, it is thus important to know how the suspended material is dispersed in the river system. However, the dynamics of suspended sediment in rivers are quite complex and, furthermore, the chlorinated organics are involved in continuous sorption and desorption processes with the river bed. Some of these processes are biotic, and the river bed acts much like a giant trickling filter. Other processes involve inflow and outflow of groundwater; in this case the river bed acts like a passive trap and a source of suspended material. Finally, chemical reactions and physical mixing can also occur between the suspended material and the bedload.

In attempting to predict the fate of the contaminants in pulp mill effluents that enter the Athabasca River, one may consider the extensive impact study that was conducted in the 1970s of the pesticide (or larvicide), methoxychlor. The objective of the study was to control black flies which were attacking cattle in the area of the Athabasca River. Fly breeding sites along the river, which were mostly downstream of the town of Athabasca, were treated with methoxychlor during 1974, 1975 and 1976. The pesticide was applied once or twice a year to maintain a concentration of 0.3 mg/l during seven and a half to fifteen minutes. The treatments were followed by extensive investigation of the distribution of methoxychlor in the river water, the river bed, and in the sediment of Lake Athabasca. The applied methoxychlor remained in emulsion close to the treatment area, but adsorption to suspended particles took place rather quickly. With increasing adsorption, the methoxychlor was subsequently lost to the moving or static bed of the river, which resulted in a smaller amount of methoxychlor in the water and suspended material. The levels of methoxychlor in the river

bedload were higher than those measured in samples of mud taken from sedimentation sites. About 17 months after the last treatment, the accumulation of methoxychlor was examined in sediments from nine sites of the Athabasca delta and twenty-one sites at Lake Athabasca. No residues of methoxychlor were identified in any of the samples analyzed.

The maximum emission of chlorinated substances from the ALPAC mill is estimated to be approximately 500 t/year (as AOX). Generally speaking about 1 to 2 % of the AOX, thus max. 5-10 t/year, has hydrophobic properties and can be extracted and measured as extractable organic chlorine (EOCl). It seems plausible that the EOCl, as well as other components of the pulp mill effluent (such as resin acids and the extremely hydrophobic chlorinated dioxins), will behave much like the methoxychlor. If this is the case, the hydrophobic substances in the downstream vicinity of the discharge point will be associated with the suspended material in the river water. Further downstream, association with both the suspended material and with material moving in the riverbed will occur.

While it seems plausible that a major part of the chlorinated organic compounds in the ALPAC mill effluent will remain in the Athabasca river bed, it is unlikely that these substances will reach 600 km downstream to the delta at Lake Athabasca, or further, to the Slave River System. This view is supported by the fact that no pollutants characteristic of pulp mill effluents could be detected during examinations of sediments from the Athabasca delta area during 1989, even though the Weldwood pulp mill at Hinton had been discharging effluents into the river since the end of 1950s. Dioxins and furans were barely detectable in one sample, but were present in sediment from a reference area at the Birch River delta. The levels of dioxins and furans were so low that the authors claimed that it "appeared to be a low level contamination over a very restricted region, or an experimental artifact". The composition of the dioxins did not match that of a pulp mill derived source.

In sediments from receiving waters of bleached pulp mill effluents one often finds gradients of EOCl and resin acids, with higher levels in those samples taken closer to the mills. In the case of the Athabasca River, however, it is doubtful that any gradients will be detected in the river bed downstream from the ALPAC mill due to the enormous amount of material in the moving river bed.

Persistence, Transformation and Degradation

The general view that chlorinated organic compounds are more persistent in the environment than non-chlorinated compounds is one of the rationales used by authorities in many countries to force the pulp mill industry to drastically reduce discharges of chlorinated organic material. Although this view may hold true in a majority of cases and, therefore, can be used as a

general guideline, recent studies have clearly demonstrated that there are many exceptions.

The widespread, strong concern regarding the persistence of chlorinated organics in aquatic environments and therefore the potential hazard they represent, is largely based on earlier studies of polychlorinated compounds such as DDT, PCBs, toxaphene and, in relation to the pulp industry, 2,3,7,8-TCDD and -TCDF, and tri- and tetra-chlorinated phenols and guaiacols. This group of compounds is clearly quite persistent in the environment and, furthermore, has other hazardous properties such as bioaccumulation potential and toxicity. It is also often argued that chlorinated organics are persistent, and hazardous, because they are man-made. It was generally believed that there was no natural biosynthesis of chlorinated organics, i.e., that all chlorinated organics found in the environment were of anthropogenic origin. However, natural production of organohalogens is now well documented for both terrestrial and aquatic environments.

Many recent observations clearly show that organohalogens are produced naturally in a variety of environmental compartments, and the question about persistence and the generally hazardous nature of such compounds must be put into perspective. An important conclusions is that not all chlorinated organics are automatically harmful; it is necessary to study each individual compound, and make specific assessments based on the relevant properties of that compound.

Returning to the problem of chlorinated organics in pulp mill effluents, it is important to remember that an alert, issued some years ago, stating that these compounds, as a group, have a severe detrimental impact on the environment, was based on studies of the composition of pulp mill effluents at that time. It is clear that a conventional chlorine bleaching plant with an inefficiently washed pulp, with a high kappa number, produced substantial amounts of highly chlorinated aromatic compounds (such as tetra-, penta- and hexachlorodioxins and furans; as well as tri- and tetrachlorophenols and -guaiacols).

However, analysis of current effluents, from processes using extended cooking, oxygen delignification, efficient washing, and a high substitution of chlorine with chlorine dioxide, shows that: (a) phenolic compounds with a lower degree of chlorination exceed those with three or four chlorine atoms per molecule; (b) effluents are no longer dominated by chloroguaiacols and chlorocatechols, but are increasingly dominated by low-chlorinated vanillins; and (c) polychlorinated dioxins and furans have virtually disappeared from the effluents discharged from most pulp mills operating today.

This substantive change in the composition of chlorinated organics in effluents (in addition to the drastic decrease of the total AOX) has one further important implication: the remaining chloro-organic compounds are much more readily biodegraded. This means that external treatment of the effluents by means of activated sludge or in an aerated lagoon, will reduce to low levels the residual amounts of AOX being discharged into the receiving water. These residual compounds will be further degraded in the receiving environment. It should, however, be noted that high-relative-molecular-mass materials in spent bleaching liquors are probably biologically rather inactive, because they cannot penetrate cell membranes of living organisms. It is an open question whether and to what degree these materials are broken down biologically and chemically to form low-relative-molecular-mass compounds possibly having detrimental biological effects. As the structure of chlorinated high-molecular-weight material has not been resolved, studies on its biodegradation and biotransformation are limited. Nonetheless, this material is susceptible to both microbiological and chemical attack.

Another important aspect of discharges of chlorinated phenolics is the transformation of these compounds by microorganisms in the environment. From an environmental impact point of view, the most interesting transformation is the O-methylation reaction, producing metabolites which are more hazardous than the original compounds. It has been clearly shown that O-methylation of halogenated phenolics is a ubiquitous reaction in the environment, and could be regarded as an alternative to degradation. The environmental significance of O-methylation comes from the fact that the metabolites (halogenated anisoles, in the case of O-methylation of halogenated phenols, and halo-veratroles from haloguaiacols) are persistent. The metabolites are much more bioaccumulative than the parent compounds – in some cases exert specific toxic action on fish – and have a strong taste and odor. This particular property of chlorinated phenolics is another good reason for minimizing to as low a value as practically possible, the amount discharged into the aquatic environment.

A further group of compounds, which are discharged from pulp mills in considerable amounts, but which so far have not been considered very persistent in the environment, are the resin acids. This view will have to be altered somewhat since high concentrations of resin acids and chlorinated resin acids have recently been found in the sediments of Swedish lakes receiving discharges from pulp mills. Sediments in Lake Vanern in Sweden contained high levels of resin acids equal to the content of EOCl. Pulp mills have discharged such substances into the lake since the 1940's. The total amount of EOCl in the surface sediment of the lake was calculated to be 114 tons, of which 3.6 tons were of natural origin. The content of chlorophenolics (phenols, guaiacols, catechols) was 0.85 tons, whereas the content of resin acids was 45 tons.

Interesting to note in this respect is that chlorinated phenolics only constituted a small fraction of the total amount of EOCl. The water residence time of the lake is 8.8 years, and if the chlorinated phenolics were very persistent the levels would have been higher. Thus it can be argued that chlorinated phenolics are effectively broken down over time.

Bioaccumulation

For most neutral organic compounds, their n-octanol/water partition coefficient (P_{ow}) is a good predictor of the bioconcentration potential. However, for polar compounds, like the chlorinated phenolics and the resin acids in pulp mill effluents, the P_{ow} value is of limited help in predicting the bioconcentration factor. Some of the neutral, chlorinated compounds related to pulp mill effluents have a very high bioconcentration potential, which can be demonstrated by the following examples of $\log_{10}$ bioconcentration factor BCF (related to fish).

Compound	BCF
2,4,6-trichloroanisole	3.9
3,4,5-trichloroveratrole	3.3
tetrachloroveratrole	4.5
2,3,7,8-TCDD	4.6

In spite of the very high bioconcentration factor of e.g., 2,3,7,8-TCDD the residence time of this compound in the fish body is not very long. The biological half-life of this compound in rainbow trout has been determined to be 15 to 48 days after the fish were returned to uncontaminated water.

Neutral chlorinated compounds, however, are relatively scarce in pulp mill effluents, which are largely dominated by polar substances. Most of these do not show any strong tendency to become concentrated in the fatty tissues of fish or other aquatic organisms. Clearly, it is not easy to monitor the occurrence of these compounds by taking samples of fish fat and analyzing them for chlorinated phenolics or resin acids for example.

The question whether toxic compounds from pulp mills will cause toxic effects in general in the Athabasca River and what the contribution of the planned ALPAC mill will be, cannot be answered explicitly since the present impact of the discharges from the Hinton and White Court mills is not known.

Analyses for the presence of chlorinated phenolic substances in fish tissues (burbot liver) from the Slave River varied between 20 and 750 ng/g based on fat weight. As a comparison, results from Sweden showed total levels of 1000 ng/g wet weight (corresponding fat weight with about 15 % fat content, 6700 ng/g) in liver tissue from perch recorded from an area outside

two pulp mills. Effects on fish populations in the same area have not been recorded.

The isomers of chlorinated phenolics with the highest concentration in burbots from the Slave River were tri-chlorinated (2,4,6) and tetrachlorinated phenols. The pulp mill specific chlorinated guaiacols were low, i.e. not exceeding 7 ng/g. Since guaiacols usually occur in much higher concentrations than chlorinated phenols in bleached pulp mill effluents the high levels of chlorinated phenols (mainly 2,4,6-trichlorophenol) in the liver of burbot from the Slave River do not seem to be of pulp mill origin. In some studies in the Finnish lake districts, including unpolluted areas, the levels of chlorinated phenols upstream of pulp mills varied between 270 and 580 ng/g in winter, and between 40 and 180 ng/g in summer on a freshweight basis in the liver of pike (Esox lucius). In the light of this the levels of chlorophenolic substances in fish from Slave River cannot be considered as abnormally high because even in unpolluted Finnish lakes the levels of these substances were higher than in the Slave River.

4.7
Human Health Effects

The pulp mills in Alberta are not located immediately above water intake points for any drinking water supply. However, it has been a concern that the drinking water supply in Fort McMurray which is located along the lower part of Athabasca River, could be adversely affected. The Canadian Water Quality Guidelines stipulate for maximum acceptable concentration for many different parameters in the raw water. The results of this project indicate that there is no risk of exceeding the maximum acceptable limits for any Canadian Water Quality parameter at Fort McMurray due to pulp mill effluents.

5
ENVIRONMENTAL IMPACTS IN NORTHWEST TERRITORIES

5.1
Water Pollution

The pulp mills in Alberta have very little effects on the water quality of Peace River, Slave River and Great Slave Lake. The effects of the ALPAC could in principle extend only to the Slave River and the Great Slave Lake but due to the size and buffering effect of the Lake Athabasca it is unlikely that any effects of chlorinated compounds would be detected in Northwest Territories (NWT). Traces of chlorinated compounds have been analysed in burbot liver but their origin and especially relation to pulp mills has not been adequately addressed.

It may be also difficult to show from which river the traces of 2,3,7,8-TCDD and 2,3,7,8-TCDF are coming from, if more detailed analyses of dioxin congeners later on show that they would be from chemical pulp mills in Alberta.

The kraft and mechanical pulp mills would not have any effect of the oxygen content of the Slave River. The AOX, phosphorus and nitrogen discharges would not have any effects at all on fisheries or eutrophication in NWT. It will be difficult to show any statistically significant increase in their concentrations, not to speak about the effects of possible small increase in concentrations.

Nevertheless, there is so much interest in NWT to study the possible effects that more monitoring of the concentrations of chlorinated dioxins and furans should be carried out after all the kraft pulp mills except for ALPAC are in full production. This interest was clearly expressed in the public hearings organised by the EIA Review Board in autumn 1989.

5.2
Human Health Effects

Identification of Risk Groups

The population of the region is relatively low in relation to the land area concerned. Major population centres down stream from Athabasca include the Fort McMurray area, where the Fort McMurray district health unit is concerned with the health issues of approximately 37,500 people. Further down the waterway, beyond the Slave River in the northwest territories, there are approximately 37,000 people who could be effected by industrial developments on the Athabasca River. The large land and low population involved will have a significant bearing on the likely impact of the ALPAC development downstream from Athabasca. Contaminants which may be carried down the river and accumulated in the food chain are likely to represent the only significant impact on human health. Any risk assessment has to be made on the basis of current knowledge on the contaminant production by the pulp and paper industry.

The available data on TCDD (or PCDD) and TCDF (or PCDF) contamination in Alberta and the Northwestern Territory is so scarce that it is very difficult to identify risk groups. However, it can be expected from experience elsewhere that in this essentially non-urban region there are two risk groups that are likely to be affected by PCDDs and PCDFs. These would be the heavy consumers of milk and the heavy consumers of fish. No information has been presented on the concentration of these contaminants on either breast milk or cow's milk in Alberta. Consequently, it is impossible to make any predictions on risks associated with heavy milk consumption. On the other hand, it is possible to assess the milk

consumption of the native populations and make some comparisons with existing literature data. A very limited amount of data is available on the concentration of these compounds in fish.

The paper, "Baseline Contaminant Levels in Selected Slave River Fish Species" indicates that the level of total dibenzodioxins and dibenzofurans are below detection limit or very low in burbot livers or longnosed suckers (Figure 5/1). These were measured in whole fish. However, the sample numbers are small and collection points are relatively far from the proposed ALPAC plant. Nevertheless, these figures provide some comparison and potential baseline for the future monitoring.

The highest concentrations of chlorinated dibenzodioxins and dibenzofurans were found immediately below the Procter & Gamble (Figure 5/2) plant and the Weldwood plant (Figure 5/3) on the Athabasca River. For 2,3,7,8-TCDD these concentrations were 5–17 ppt and 3–17 ppt, respectively. Correspondingly, the 2,3,7,8-TCDF concentrations ranged from 18–290 ppt and 16–1 ppt. Clearly, more samples are needed for baseline determinations. However, these values will permit a preliminary estimate of potential intake of TCDD and TCDF.

FIGURE 5/1
TCDD and TCDF Concentrations in
Fish Samples from the Slave River

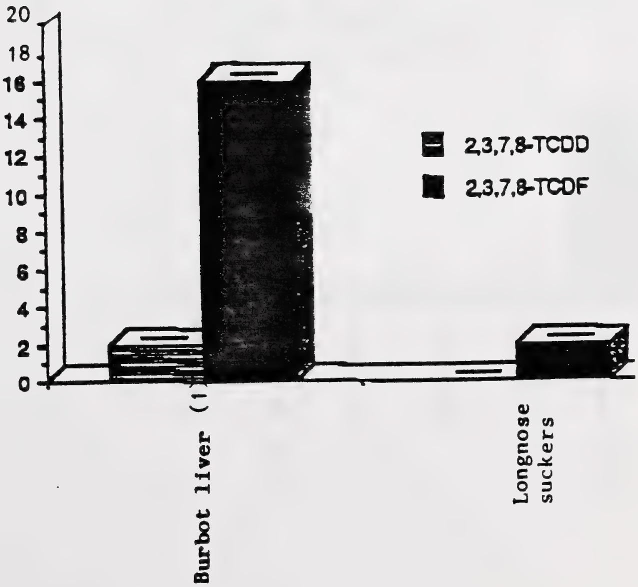


FIGURE 5/2
TCDD and TCDF Concentrations in Various Samples
Below the Procter and Gamble Pulp Mill of the Peace River

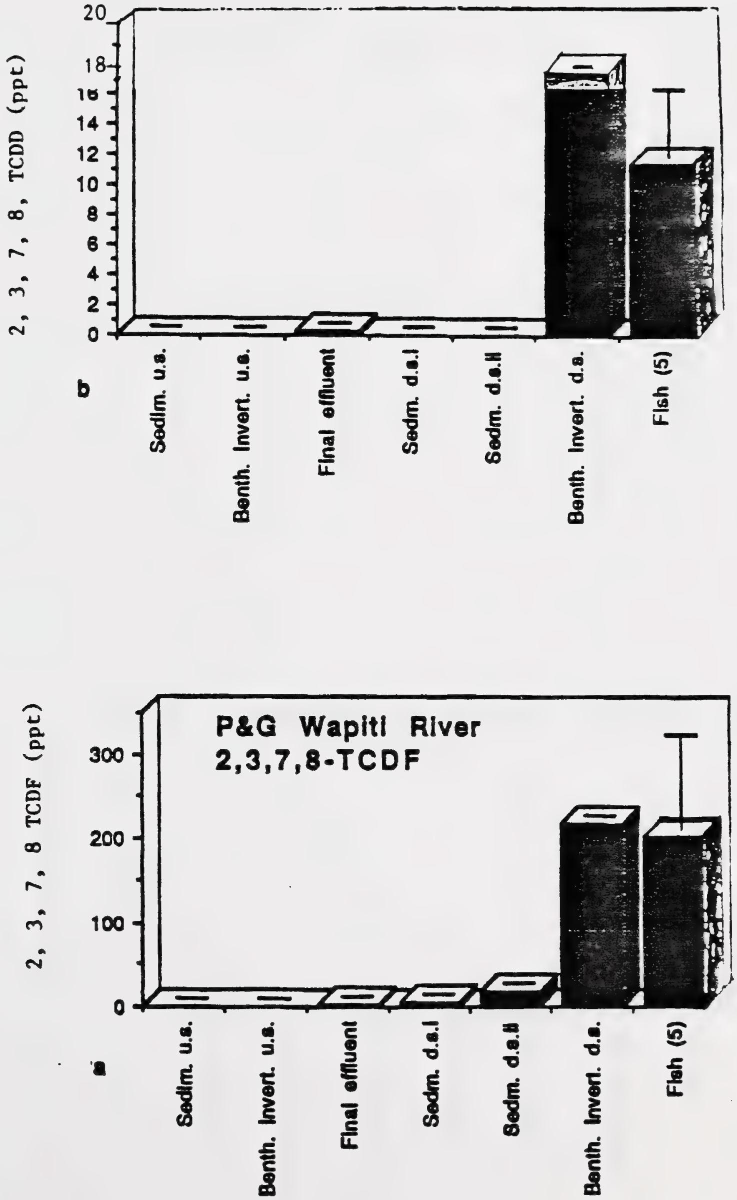
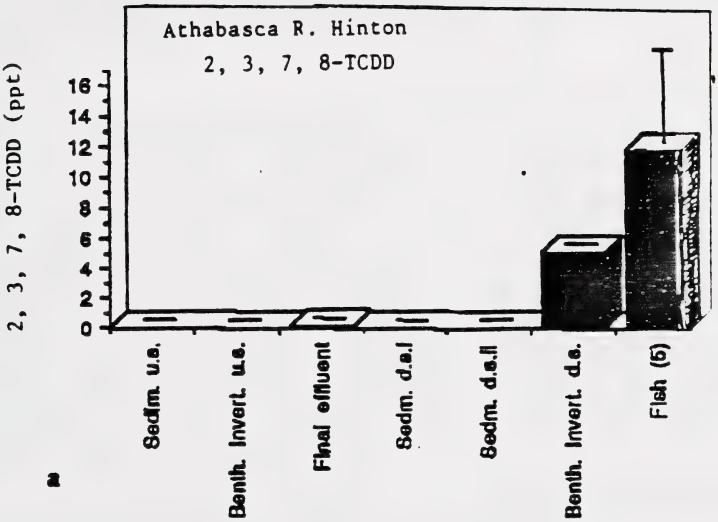
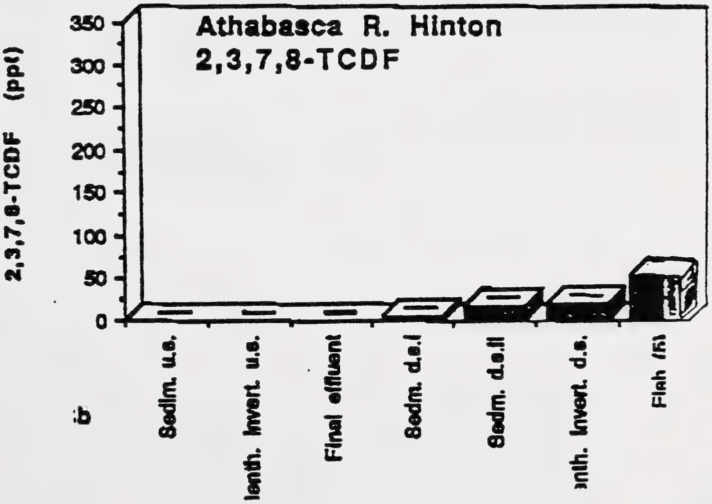


FIGURE 5/3
TCDD and TCDF Concentrations in Various Samples
Below the Weldwood Pulp Mill at the Athabasca River





Native Albertan Country Food Fish Consumption

An issue that has been given a great deal of prominence in the hearings, is the fact that the native population of Northern Alberta and the Northwest Territory use fish as a major part of their diet. Consequently, from experience in other parts of the world, they would appear as a group most at risk.

A lot of anecdotal information was presented to the review panel relating to the dietary habits of the aboriginal people of the region. However, a very important document did not get presented to the hearings, namely the PhD thesis of Eleanor Wein. This extensive study of the use of country foods by the Northern Aboriginal people is extremely valuable providing a description of both the quantity and quality of fish consumed by native peoples living in Fort Smith, NWT, and Fort Chipewayan, Alberta., The title of the thesis is "Nutrient Intakes and Use of Country Foods by Native Canadians near Wood Buffalo National Park" presented to the Faculty of Graduate Studies of the University of Guelph. The author has collected information on the dietary habits of the population of this region by using dietary recalls as a method of accumulating the data.

In this study, people were divided into 3 main age groups (shown below) and fish consumption patterns differed with grouping.

Adolescents & Young Adults = 13–24 years of age
Middle Adults = 25–49 years of age
Older Adults = 50–86 years of age

The largest fish consumers were the older adult males who consumed 36 g of fish per day at a frequency of 0.2 times/day.

The adolescents and young adults plus middle adults (ages 13–49) represent a group that will be most at risk due to any future pollution. Their fish flesh consumption pattern is shown below:

TABLE 5-1
Fish Consumption by Adolescents and
Young Adults Plus Middle Aged Adults

Species	Total Eaten (muscle tissue only)	Amount Eaten (g/week)
Whitefish	51.5 %	13.3
Pickeral	14.5 %	3.5
Pike	14.5 %	3.5
Lake Trout	9.7 %	2.8
Goldeye	3.2 %	0.7
Sucker	3.2 %	0.7
Others (Loch, fish eggs, inconnu	3.3 %	1.4
Total	100 %	25.9

Note: The top six fin fish make up 96.7 % of total fish consumption, burbot are not listed, and no mention is made of fish organ consumption (such as burbot liver) in this study, even though all sources of food intake were studied including organ consumption from caribou, moose, bison, bear and goose. This is relevant as concerns have been expressed that the native population would have a high intake of contaminants accumulated in the liver of burbot.

Dr Wein's thesis gives the consumption figures for 'country foods' giving the total frequency as 0.6 times per day, i.e. every other day some country foods are included in the diet. That means that there are significant amounts of processed foods in the Indian diet and they contribute significantly to the overall intake assessment. Even taking into account the total fish consumption (from other sources) as well as the fish from the local sources, i.e. country food fish the local Indians appear not to be eating fish in larger amounts than other Canadians. The intake of fish for the "average" Canadian is given as 98 g/week.

It may be of importance to note the difference between young adults, middle adults and older adults. There are great variations in fish consumption (from 7 to 36 g/day with 0.05-0.2 times per day). This is reflected also in the beliefs study where older people appear to think of fresh fish as one of the healthier staple foods in their diet. Simultaneously, the young appear to rely on modern ideas of fruits and vegetables and this is also reflected in their choices and intakes. We should keep in mind that although the young are by far the most important group in terms of exposure, all possible special groups and exposure levels must be taken into account. Therefore, the calculations have been performed to represent all age groups. It would be preferable to take into account the upper 10th percentile instead of the upper 20 %. However, this has not been possible from the presented data.

Intake estimates may be made in various ways.

1. When a contaminant is known to be in the food but cannot be detected by analysis, the maximum contaminant concentration is assumed to be equal to the lower detection limit. These values are then used as the basis for calculations, i.e. using in this case the highest observed dioxin or furan concentrations as the basis for intake estimates.

2. Another extreme would be to multiply the highest found concentration with the highest amount of food item consumed to provide a high intake estimate, i.e. here taking highest concentrations of dioxins and highest fish consumption figures from older adults together and maybe even maximizing it to the upper 10 or 20 % consumers.

3. The only accurate way is to conduct duplicate meal (portion) studies by analyzing samples from populations at risk, i.e. native Indians in the Athabasca area.

As far as dietary recalls are considered as nutritional intake study methods one has to remember that there are both random errors and systematic errors often included in the result. It has been estimated that coding errors range from 3-27 %, estimated food weights have an error range of 20-50 % and reporting errors have been observed ranging from 4-400 % in the 24 hour dietary recall method. And these include just a few possibilities which means that dietary recalls need to be conducted by trained and experienced interviewers as well as careful initial planning and training of all other workers involved. From the material available it is not possible to assess all the likely sources of error. The local native subjects may have been difficult for a student interview, thus altering the results in an unexpected way. The figures require extremely careful interpretation; estimates should tend to overestimate any possible extremes and also indicate variation between different dietary subgroups. Consequently the team has made comparisons with the Nordic fish consumption which is very much higher than the high Canadian fish consumption or the fish consumption observed in the Athabasca/Slave River region. It is notable that even the high Nordic consumers would not exceed the TWI for TCDD if their fish consumption consisted only burbot liver from the Slave River.

It would appear extremely unlikely that TCDD TWI's would be exceeded by the general population eating fish from mixed sources. There is not adequate data available for Alberta to asses the overall dibenzodioxin and dibenzofuran intakes in terms of TCDD toxic equivalents (TEQ). Even if somehow all fish consumed contained 20 ppt of TEQ in their flesh which is the Ontario maximum consumption limit, the level of local fish consumption would only result in the intake of 10 % of the TEQ allowed by the Ontario ADI (allowable daily intake) of 0.01 ng/kg/d. There is no evidence that would suggest exposures exceeding these levels down stream of Athabasca.

Thus in conclusion, the native peoples of the Lake Athabasca area (Fort Chipewyan) and of the Wood Buffalo National Park area (Fort Smith) have present day fish consumption patterns which are significantly lower than the average Canadians (roughly one quarter) and that as a result they are very unlikely to be at risk of exceeding allowable intakes of chemicals such as dioxins as a result of fish consumption, irrespective of whether or not the ALPAC project is allowed to proceed.

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